DOCUMENT RESUME

EM 008 937

ED 050 577

AUTHOR	Stifle, Jack
TITLE	A Plasma Display Terminal.
INSTITUTION	Illinois Univ., Urbana. Computer-Based Education Lab.
SPONS AGENCY	Joint Services Electronics Program, Fort Monmouth, N.J.
REPORT NO	CERL-X-15
PUB DATE	Mar 71
NOTE	33p.
EDRS PRICE	EDRS Price MF-$0.65 HC-$3.29
DESCRIPTORS	Audio Equipment, Computer Assisted Instruction, *Computer Graphics, *Computers, *Display Systems, Electronic Equipment, *Input Output Devices, Projection Equipment

ABSTRACT

A graphics terminal designed for use as a remote computer input/output terminal is described. Although the terminal is intended for use in teaching applications, it has several features which make it useful in many other computer terminal applications. These features include: a 10-inch square plasma display panel, permanent storage of information on the display screen without flicker, self-contained character and line generators, an optional random-access audio response unit, and a random-access slide projector. The terminal can send and receive data on voice grade telephone circuits. The unit has a character-writing speed of 180 characters per second and the capability of displaying up to 2048 characters on the screen. It has a line-drawing speed of more than 600 inches per second and a character repertoire of 256 characters. The operating modes of the terminal, including commands, are explained, as are possible sources of and the output word format for terminal-generated data. (JK)

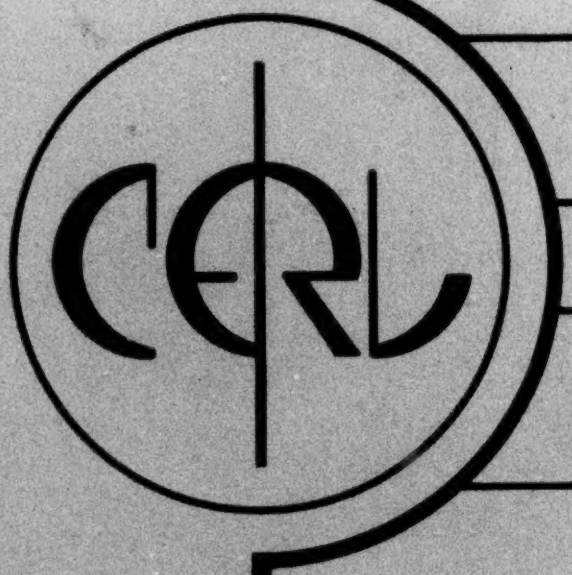
ED050577

CERL REPORT X-15

MARCH, 1970
REVISED MARCH, 1971

A PLASMA DISPLAY TERMINAL

JACK STIFLE



Computer-based Education Research Laboratory

University of Illinois Urbana Illinois

EM 008 937

1

ED050577

This work was supported in part by the Joint Services Electronics Program (U.S. Army, U.S. Navy, and U.S. Air Force) under Contract DAAB 07-67-C-0199; in part by National Science Foundation Grant USNSF GJ 81; in part by the Advanced Research Projects Agency under grant ONR Nonr 3985(08); in part by Project Grant NPG-188 under the Nurse Training Act of 1964, Division of Nursing, Public Health Service, U.S. Dept. of Health, Education and Welfare; and in part by the State of Illinois.

Reproduction in whole or in part is permitted for any purpose of the United States Government.

Distribution of this report is unlimited.

U.S. DEPARTMENT OF HEALTH, EDUCATION & WELFARE
OFFICE OF EDUCATION
THIS DOCUMENT HAS BEEN REPRODUCED EXACTLY AS RECEIVED FROM THE PERSON OR ORGANIZATION ORIGINATING IT. POINTS OF VIEW OR OPINIONS STATED DO NOT NECESSARILY REPRESENT OFFICIAL OFFICE OF EDUCATION POSITION OR POLICY.

A PLASMA DISPLAY TERMINAL*

Jack Stifle

Coordinated Science Laboratory

and

Computer-Based Education Research Laboratory

University of Illinois, Urbana, Illinois 61801

ABSTRACT

This report describes a graphics terminal designed for use as a remote computer input-output terminal. The terminal features a plasma display panel, self-contained character and line generators and the ability to communicate over voice grade telephone circuits.

ED008937

*This work was supported in part by the Joint Services Electronics Program (U.S. Army, U.S. Navy, and U.S. Air Force) under Contract DAAB-07-67-C-0199; and in part by National Science Foundation Grant USNSF GJ 81.

ACKNOWLEDGMENTS

Several people contributed their talents to the development of this terminal. To Ray Trogdon goes the credit for the development of the very important panel decoding and driving circuits. He was assisted by Jim Knoke who was responsible for construction of these circuits.

Frank Propst and Garrie Burr were responsible for the slide projector and the design of the terminal enclosure.

Leonard Hedges supervised the fabrication of the terminal electronics and was assisted in the actual construction by George Crawford, Fred Holy, and Rich Slavens.

Thanks are due Sandra Bowles, Jean Ciesa, and Terry Gabrielse for their help with the publication.

CHAPTER 1 - DESCRIPTION Page

1.0 INTRODUCTION..... 1

1.1 TERMINAL DESCRIPTION..... 2

1.2 AUXILIARY EQUIPMENT..... 5

CHAPTER 2 - OPERATING MODES

2.0 WORD FORMAT..... 7

2.1 CONTROL WORD..... 7

2.2 MODE WORD..... 10

2.3 MODE 0..... 11

2.4 MODE 1..... 11

2.5 MODE 2..... 12

2.6 MODE 3..... 13

2.7 CONTROL CHARACTERS..... 16

2.8 ERROR CONTROL..... 19

CHAPTER 3 - TERMINAL GENERATED DATA

3.0 DATA SOURCES..... 20

3.1 OUTPUT WORD FORMAT..... 20

CHAPTER 1 - DESCRIPTION

1.0 Introduction

This report describes the proposed student terminal (remote computer terminal), designed for use in the PLATO IV computer-based-education system. Although the terminal is intended for use in teaching applications, it has many features which make it useful in many other computer terminal applications. These features include:

1. A 10-inch square plasma display panel that is readable in a brightly lighted room without eyestrain.
2. Permanent storage of information on the display screen without flicker. Absolutely no refreshing of the display panel by the computer is required.
3. Self-contained character and line generators.
4. A character writing speed of 180 characters per second and the capability of displaying up to 2048 characters on the screen.
5. A line drawing speed in excess of 600 inches per second.
6. A character repertoire of 256 characters, 128 of which are alterable via the computer program.
7. The ability to transmit and receive data on voice grade telephone circuits.
8. A random access slide projector for rear projection of static information on the display screen.
9. Additional input-output channels for the control of auxiliary equipment.
10. An optional random-access audio response unit.

The single most expensive item in any cathode-ray tube (CRT) display system is the memory needed to refresh or "hold up" an image on the face of the CRT. As many as 4K 18-bit words of memory (1 μs) may be required to "hold up" an image occupying as little as 2% of the available space on a display with 512

line resolution. At a cost of 5¢ per bit such a memory becomes a $3600 item. Even before including the costs of the CRT, the digital to analog (DA) converters, and the deflection amplifiers, all of which can easily add up to an additional $1000, a cost level has been reached that is prohibitive for most large scale users of graphic display terminals.

Fortunately, the plasma display panel[1,2] with its inherent capability storing information on the display screen eliminates entirely the costly items mentioned above. This inherent memory and the digital nature of the plasma panel offers for the first time the promise of low cost graphical display terminals. Preliminary estimates indicate, for example, that the terminal described in this report can be produced in quantity for less than $2500. This terminal cost is almost 1/3 less than the cost of just the memory required to operate a comparable graphical CRT display.

1.1 Terminal Description

A block diagram of the prototype terminal is shown in Figure 1.0. The terminal input section contains both a parallel and a serial input port. The parallel port is an optional feature used mainly for engineering purposes. At present, this port is designed to interface with a CDC 1604 Computer. The serial input port is designed to accept data arriving at a rate of 1200 bits/second in the form of a frequency-modulated (fm) signal, which permits

---

[1] D. L. Bitzer, and H. G. Slottow, "The Plasma Display Panel - A Digitally Addressable Display with Inherent Memory", Proceedings, Fall Joint Computer Conference, San Francisco, California, November 1966, p. 541.

[2] B. M. Arora, D. L. Bitzer, H. G. Slottow, and R. H. Willson, "The Plasma Display Panel: A New Device for Information Display and Storage", Proceedings 8th National Symposium of the Society for Information Display, May 1967, p. 1.

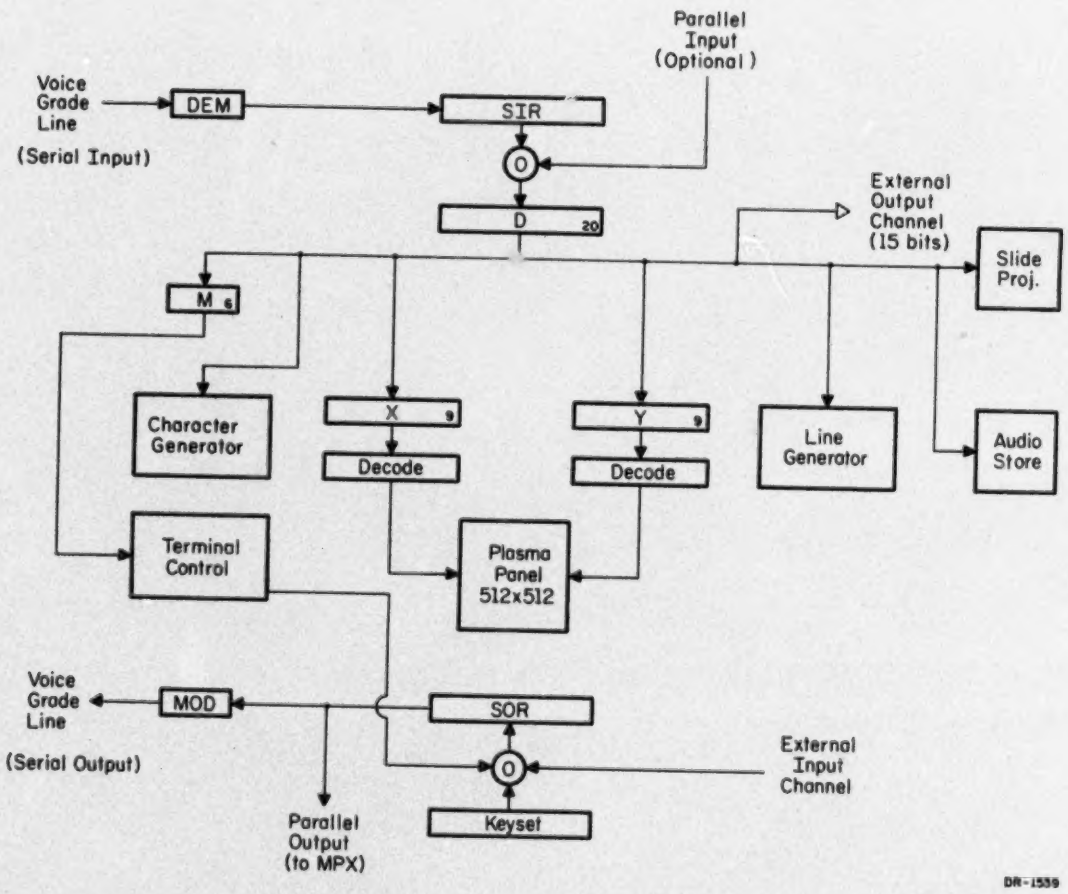


Figure 1.0 Terminal Block Diagram

the terminal to operate on voice grade (Schedule 4) telephone circuits. The terminal word size is 20 bits and therefore the terminal word rate is 60 words per second. The terminal word format is discussed in Chapter 2.

The demodulator recovers the data from the fm signal and shifts the data into the serial input register (SIR). After a full word has been assembled in the SIR it is transferred to the Data (D) Register.

The 20-bit D register is the distribution center of the terminal. From this register data may be transferred to all internal sections of the terminal as well as any external equipment connected to the terminal.

The 6 bit mode register (M) is analogous to the instruction register in a digital computer. This register directs the Terminal Control section in the processing of incoming data. Terminal Control provides the timing and control signals for controlling the flow of data within the terminal. Four modes of operation are available and are discussed in Chapter 2.

The data is displayed on a Digivue* Plasma Display Panel. This panel is a 10-inch square panel containing 512 addressable points along each axis or a total of 262,144 points. The address of any point on the panel is specified by the contents of the 9 bit X and Y registers. The outputs of these registers are sent to the decoding and driving circuits which drive the display panel.

The line generator contains the circuits used in plotting lines on the panel. Lines of any length may be drawn at the rate of 60 lines per second.

The character generator contains four memories each containing the points for plotting 64 characters or a total of 256 characters. Two of the memories are read-only memories (ROM) and two are random access (RAM).

---

*Trade-mark of Owens-Illinois, Inc.

In the latter case the memories are loaded by the computer with special character or graphical data as required by the terminal user. Characters are plotted at a rate of 180 per second.

A 64 character keyboard provides the terminal operator with an input link to the computer center. Data from the keyboard is entered into the serial output register (SOR). From the SOR data is shifted into the modulator where it is encoded as an fm signal for transmission to the computer center.

Two additional inputs to the SOR are provided. One port permits Terminal Control to transmit terminal condition information to the computer while the other port provides access to the computer center for externally connected equipment.

In many installations several terminals may be grouped together and share a common link with the computer center. In such cases, data is taken from the parallel output port on the SOR and transferred to a multiplexor where it is encoded and transmitted to the center.

1.2 Auxiliary Equipment

Three 15 bit output channels are provided to permit operation of external equipment.

One channel is used to transmit data to a random access slide projector which can project slides on the rear of the plasma display panel. The slide projector will contain a 256 slide memory with an access time of .2 second.

A second channel may be used to address an audio response unit. The audio unit will, upon command from the computer center, play back a message to the terminal operator. Up to 15 minutes of prerecorded audio messages

may be available with an average access time of .5 second.[3]

Other types of equipment which might be attached to the terminal include printers, or other hard copy devices and various types of data acquisition and recording equipment.

[3] D. L. Bitzer and D. Skaperdas, "A Random Access Audio Device", CERL Report X-13 (Computer-Based Education Research Laboratory, University of Illinois), (in preparation).

CHAPTER 2 - OPERATING MODES

2.0 Word Format

The data to be processed by the terminal consists of 20 bit words with the format shown in Figure 2.0.

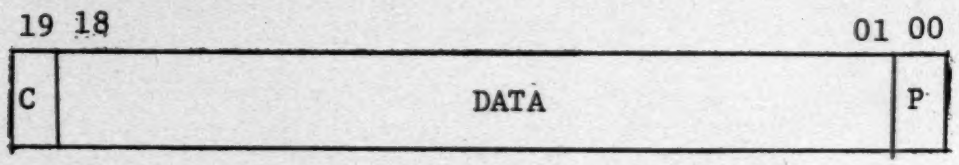


Figure 2.0 Terminal Word Format

Bit 00	Parity bit - odd parity
Bits 01 - 18	Data
Bit 19	Control bit - 0 = control word - 1 = data word

Terminal words may be of two types; control words and/or data words. Data words (C = 1) contain the data to be processed by the terminal while control words (c = 0) are instructions used to establish certain conditions within the terminal.

2.1 Control Word

The control word format is shown in Figure 2.1.

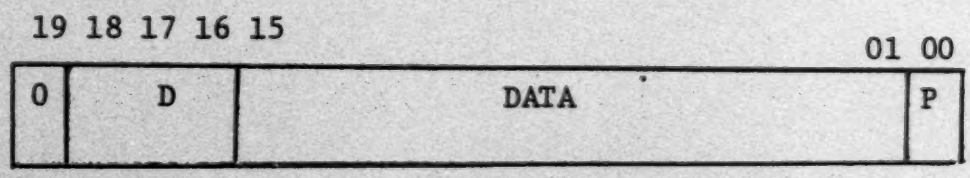
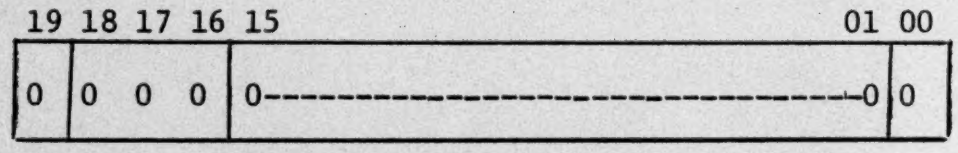


Figure 2.1 Control Word Format

Bits 01 - 15	Data
Bits 16 - 18	Destination of data within the terminal

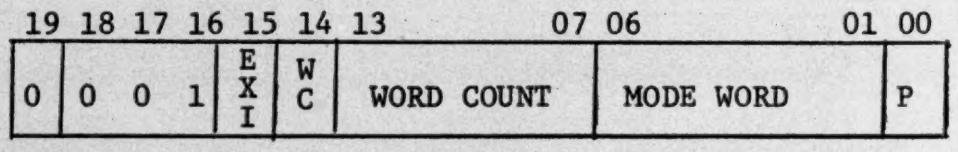
The destinations are described below.

D = 000 (NOP)



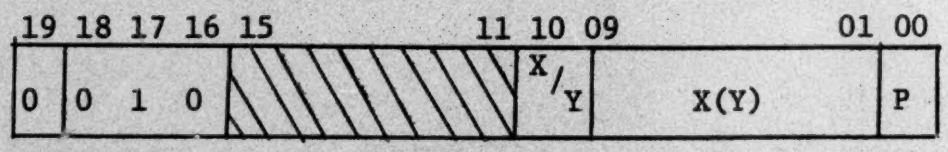
This word is a NOP (no-operation) instruction. The word is input by the terminal but the terminal condition is not altered in any way.

D = 001 (LDM) Load Mode



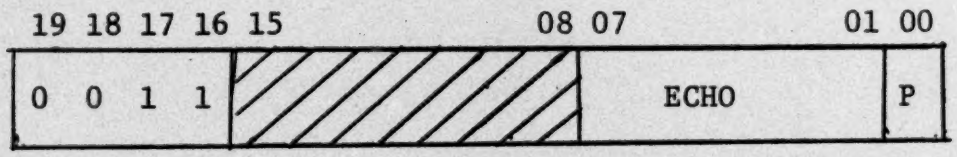
This instruction loads the Mode register (M) with bits 01-06. In addition, if bit 14 (WC) is a "1" the Word Count register will be loaded with bits 07-13. The mode word is described in Section 2.2 and the Word Count in Section 2.8. Bit 15 is used to activate the external input channel. If this bit is a "1" data may be transmitted from external devices, if it is "0" data may be transmitted only by source, internal to the terminal (See Chapter 3).

D = 010 (LDC) Load Co-ordinate



This instruction loads the X register (bit 10 = 0) or the Y register (bit 10 = 1) with bits 01-09. Bits 11-15 are unused.

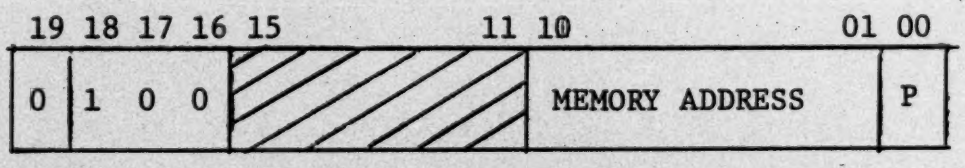
D = 011 (LDE) Load Echo



This instruction loads the terminal output register (SOR) with bits 01-07. This word is then transmitted back to the computer center.

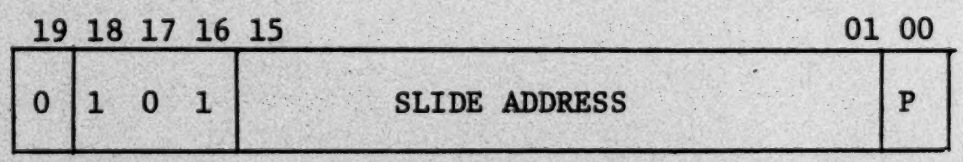
Programming Note: This instruction should not be sent to the terminal at a rate greater than once every 32 words. (Once every 64 words if external input devices are present at the terminal.) Exceeding this rate may cause erroneous data to be returned to the computer center.

D = 100 (LDA) Load Memory Address



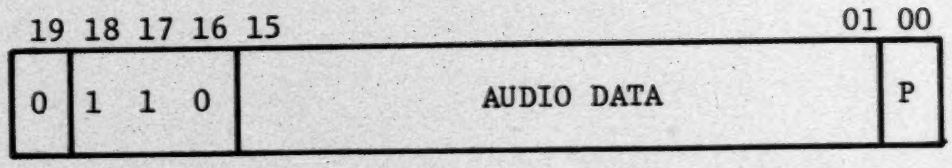
This instruction loads the Memory Address Register (MAR) with bits 01-10. Bits 11-15 are unused. This data word specifies the first storage address to be used upon entry into a Mode 2 operation. See Section 2.5.

D = 101 (SSL) Load Slide



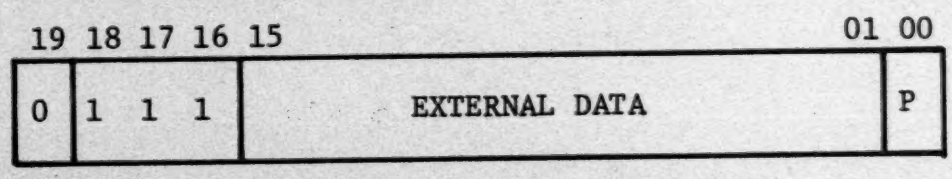
This instruction is used to display a slide on the plasma panel. Bits 01 - 15 are sent to the slide projector when they are used for slide addressing or other projector control operations.

D = 110 (AUD) Load Audio



This instruction is used to control the audio response unit. Bits 01 - 15 are sent to the audio unit where they may be used for message addressing or other control operation.

D = 111 (EXT) Load External Channel



This instruction transfers bits 01 - 15 to any equipment attached to the external output channel of the terminal.

2.2 Mode Word

For each mode of terminal operation there is an associated mode word which directs the terminal processing of incoming data. Once placed in any given mode the terminal remains in that mode until receipt of a new LDM instruction. The mode word format is shown in Figure 2.2.

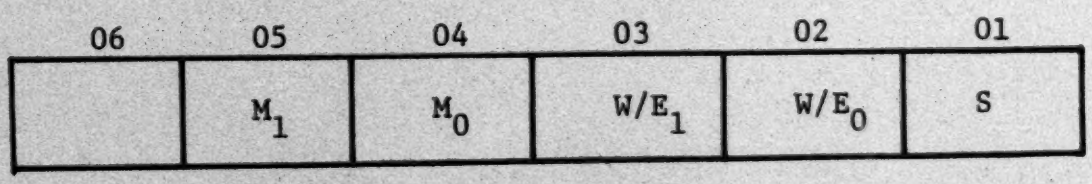


Figure 2.2 Mode Word Format

Bit 01	Screen Command. If this bit is a "1", the entire display panel is erased at the time the Mode Word is loaded into the M register.
Bits 02 - 03	Select write or erase function as follows:

W/E_1	W/E_0	
X	0	Erase
0	1	Write
1	1	Write; suppress all background erase operations. This operation is described in more detail in Section 2.6.

Bits 04 - 05	Specify operating mode
Bit 06	This bit is unused.

2.3 Mode 00

Mode 0 is a point plotting mode. Each mode 0 data word (Figure 2.3) specifies the address of a point on the panel to be written or erased. The W/E_0 bit in the mode word determines which operation is performed.

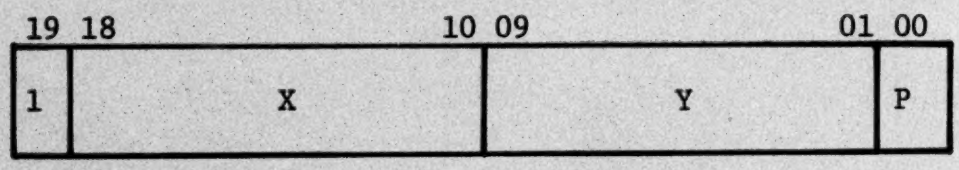


Figure 2.3 Mode 0 Data Word

2.4 Mode 01

Mode 1 is a line drawing mode. Each data word, Figure 2.4, specifies the terminal coordinates of a line, the origin of which is contained in the X and Y registers.

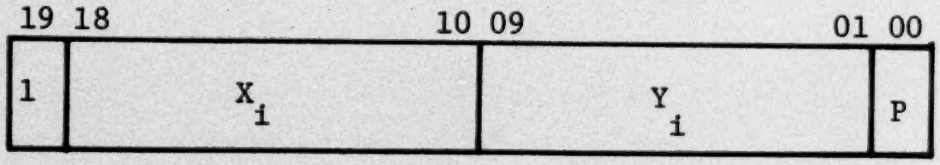


Figure 2.4 Mode 01 Data Format

The terminal point of a given line is also interpreted as the origin of the next line. Line origins may be relocated, however, by the use of the LDC command without exiting from Mode 01.

An example of a Mode 01 operation is shown in Figure 2.5

2.5 Mode 10

Mode 2 is a load terminal memory mode. Each mode 2 data word (Figure 2.6) contains a 16 bit word to be stored in the memory location specified by the present contents of the memory address register (MAR). Up to 1024 16 bit words may be stored in the the terminal. After the data has been stored

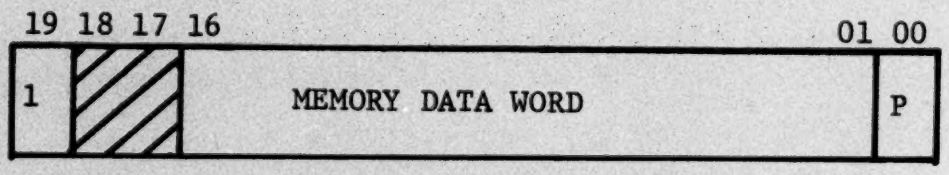


Figure 2.6 Mode 2 Data Word

the MAR is automatically incremented by 1. Thus, data may be stored sequentially in memory by transmitting only Mode 2 data words. The contents of the MAR may be changed at any time via the LDA instruction.

The data, when displayed on the panel, appears as a vertical column with bit 01 at the bottom and bit 16 at the top. The stored data is displayed via Mode 3 which is described in the next section.

2.6 Mode 011

Mode 3 is a character plotting mode. The data words in this mode contain 3-6 bit character codes as shown in Figure 2.7.

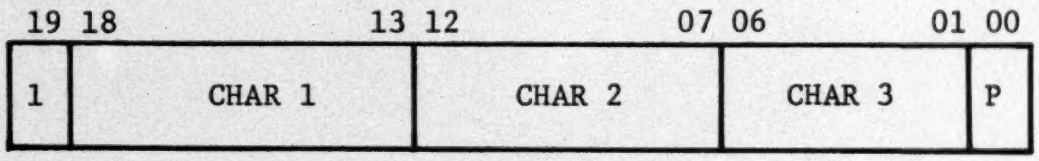


Figure 2.7 Mode 3 Data Word

Four 64 character memories are provided in the terminal. Memories M_0 and M_1 are read-only memories (ROM) which contain the characters shown in Table 2.1. Memories M_2 and M_3 each contain 512 words, 16 bits, the contents of which may be loaded via Mode 2. The contents of M_2 and M_3 are interpreted by Mode 3 as 64 arrays of 8 x 16 bits each. Thus, a character called from M_2 or M_3 actually causes the contents of 8 succeeding memory locations to be displayed on the panel.

Characters from M_0 and M_1 are also plotted within an 8 x 16 array which includes character and line spacing. See Figure 2.8.

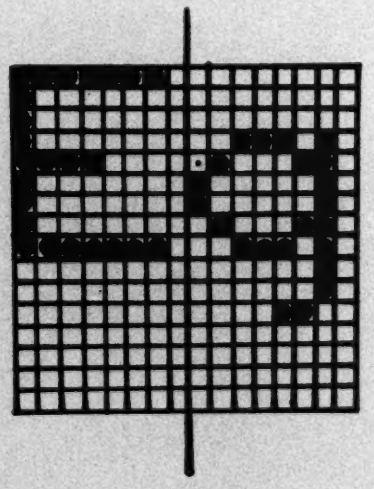
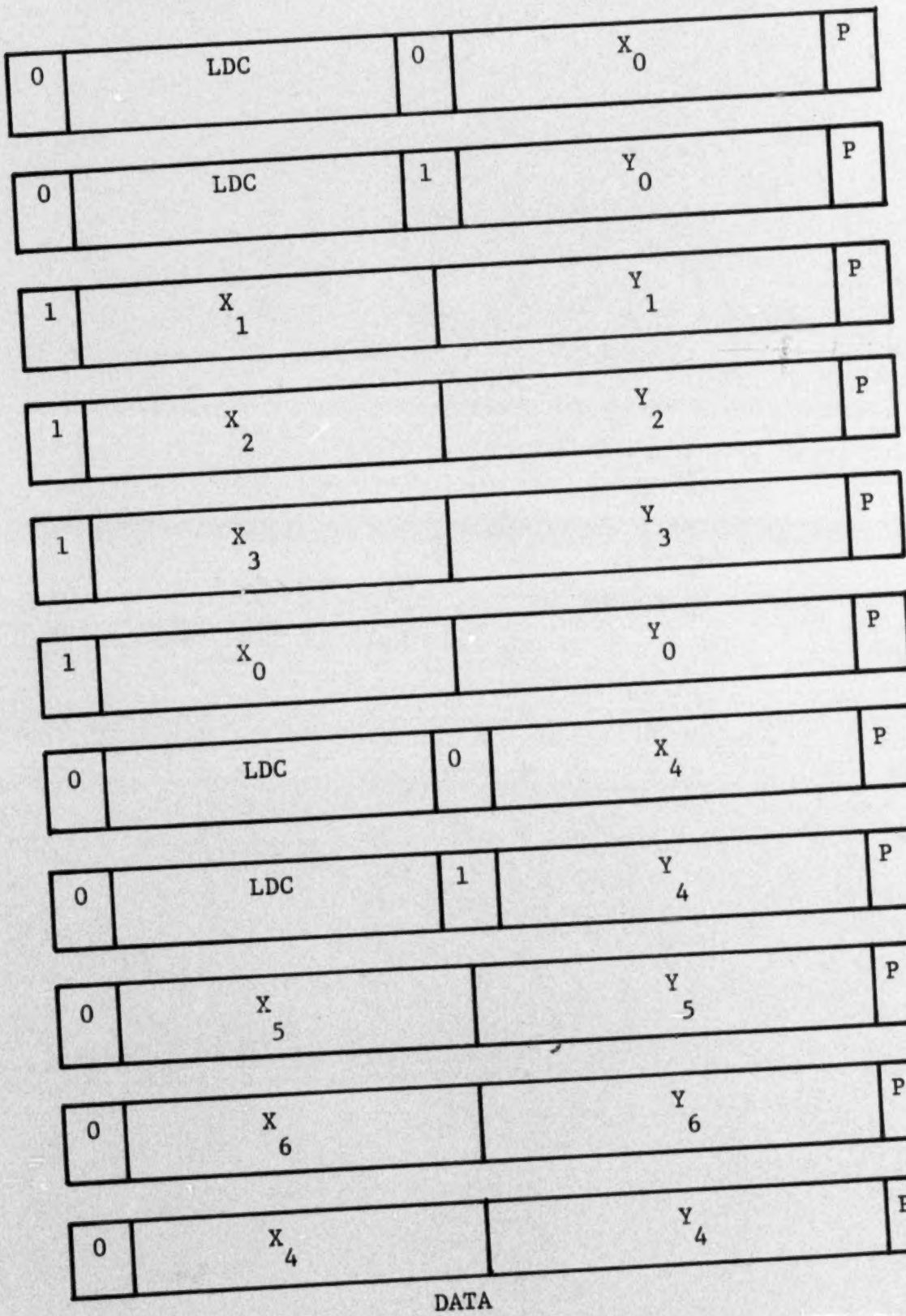
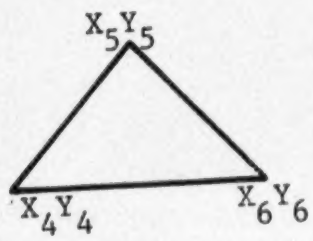
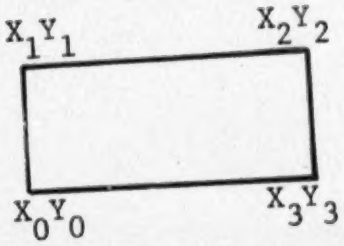


Figure 2.8 Character Matrix







DISPLAY

Figure 2.5 Mode 01 Example

BCD Code	M_0	M_1	M_2	M_3
00	SPACE	SPACE		
01	A	#		
02	B	$		
03	C	%		
04	D	&		
05	E	→		
06	F	←		
07	G	↑		
10	H	↓		
11	I	-		
12	J	|		
13	K	||		
14	L	~		
15	M	∿		
16	N	¨		
17	O	^		
20	P	∞		
21	Q	o		
22	R	→		
23	S	'		
24	T	α		
25	U	β		
26	V	∂		
27	W	μ		
30	X	¶		
31	Y	σ		
32	Z	ω		
33	:	{		
34	;	}		
35	'	Δ		
36	?	Θ		
37	!	Σ		

BCD Code	M_0	M_1	M_2	M_3
40	"	∅		
41	a	1		
42	b	2		
43	c	3		
44	d	4		
45	e	5		
46	f	6		
47	g	7		
50	h	8		
51	i	9		
52	j	≡		
53	k	=		
54	l	≈		
55	m	∿		
56	n	≠		
57	o	>		
60	p	<		
61	q	≥		
62	r	≤		
63	s	x		
64	t	*		
65	u	/		
66	v	+		
67	w	-		
70	x	√		
71	y	o		
72	z	[		
73	(	]		
74	)	,		
75	,	.		
76	.			
77	UNCOVER	UNCOVER	UNCOVER	UNCOVER

Table 2.1 Character Codes

Character write/erase is controlled by the write/erase bits in the mode word. If $W/E_0 = 1$, characters are written; if $W/E_0 = 0$, characters are erased. If $W/E_1 = 0$, the background or normally unfilled portion of each character matrix will be erased, if $W/E_1 = 1$ the background remains unaltered.

Up to 32 lines of 64 characters each may be plotted for a total of 2048 characters. In comparison, a typical page of double spaced type consists of 27 lines of 72 characters or a total of 1944 characters.

2.7 Control Characters

The "uncover" code (77) is used to gain access to 12 control characters. These characters are useful in controlling display format in Mode 3 operations.

Upon receipt of a 77 code, the terminal interprets the next character code as a control character rather than a memory address. Following execution of the control character normal Mode 3 operations are resumed. A description of each control function is given below.

Uncover (77)

This code instructs the terminal to obey the next character address as a control function. If several uncover codes are sent in sequence, the first non-uncover code will be treated as the control character.

Backspace (10)

This character decreases by 8 the panel x address, i.e., moves one character position to the left. A backspace over a displayed character does not erase the character.

Tab (11)

This character increases by 8 the panel x address, i.e., moves one character position to the right. A tab over a displayed character does not erase the character.

Line Feed (12)

This character decreases by 16 the panel y address, i.e., moves down one character position. A line feed over a displayed character does not erase the character.

Vertical Tab (13)

This character increases by 16 the panel y address, i.e., moves up one character position. A vertical tab over a displayed character does not erase the character.

Form Feed (14)

This character sets the panel address to the upper left corner (x = 0, y = 496). This is the first character position on the top line of the display. No displayed data is erased in this operation.

Carriage Return (15)

This character clears (sets to 0) the panel x address and decreases by 16 the y address. The screen address is thus set to the first character position on the line immediately below the present line. No displayed data is erased in this operation.

Superscript (16)

This character increases the panel y address by 5. All characters received following this code appear as shown in Figure 2.9. This selection may be removed by receipt of a subscript (17) code. No data is erased in a subscript operation.

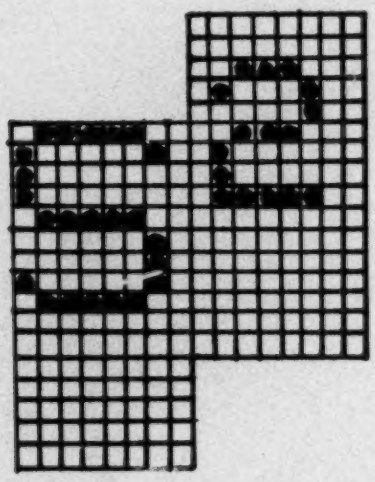


Figure 2.9 Superscript Operation

Subscript (17)

This character decreases by 5 the panel y address. All characters received following this code appear as shown in Figure 3.0. This character may be used to remove a superscript selection (16) and the superscript code may be used to remove this selection. No data is erased in a superscript operation.

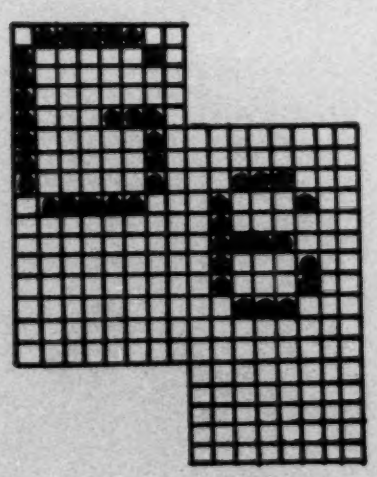


Figure 3.0 Subscript Operation

Select M_0 (20)

This code selects character memory 0. All succeeding characters will be read from the memory until receipt of a different memory select code.

Select M_1 (21)

This code selects character memory 1. All succeeding characters will be read from this memory until receipt of a different memory select code.

Select M_2 (22)

This code selects character memory 2. All succeeding characters will be read from this memory until receipt of a different memory select code.

Select M_3 (23)

This code selects character memory 3. All succeeding characters will be read from this memory until receipt of a different memory select code.

2.8 Error Control

Contained within the terminal is a 7 bit Word Count (WC) register, which maintains a record of the number of non-NOP words received by the terminal. Each time a non-NOP word is transferred into the terminal the Word Count is incremented by 1.

Upon receipt of a word with a parity error the terminal enters the ABORT mode of operation. In this mode the terminal repeatedly (approximately twice per second) transmits the contents of the WC to the computer. The WC will contain the address of the word containing the error.

Once in the ABORT mode the terminal will refuse to accept any further information except for a LDM instruction with bit 14 a "1". Receipt of this word will clear the ABORT mode and return the terminal to normal operation.

CHAPTER 3 TERMINAL GENERATED DATA

3.0 Data Sources

Data may be generated by any of three sources within the terminal or by an external device connected to the external input channel. Internal sources of data on:

1. The Word Count register (See Section 2.8)
2. The echo code. See LDE instruction in Section 2.1
3. The keyboard. The keyboard contains 64 keys as shown in Figure 3.0 and has the coding shown in Figure 3.1

3.1 Output Word Format

The data transmitted from the terminal consists of 9 bit words with the format shown in Figure 3.2.

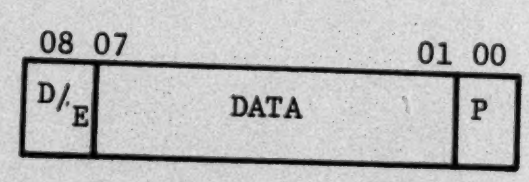


Figure 3.2 Keyset Word Format

Bit 00 — Parity bit - odd parity

Bits 01-07 — Data Field

Bit 08 — Identifier Bit. This bit identifies the data as follows:

0 = valid piece of data from keyboard, external channel, or echo code.

1 = data field contains word count specifying a word which arrived at the terminal containing an error.

Standard Keyboard

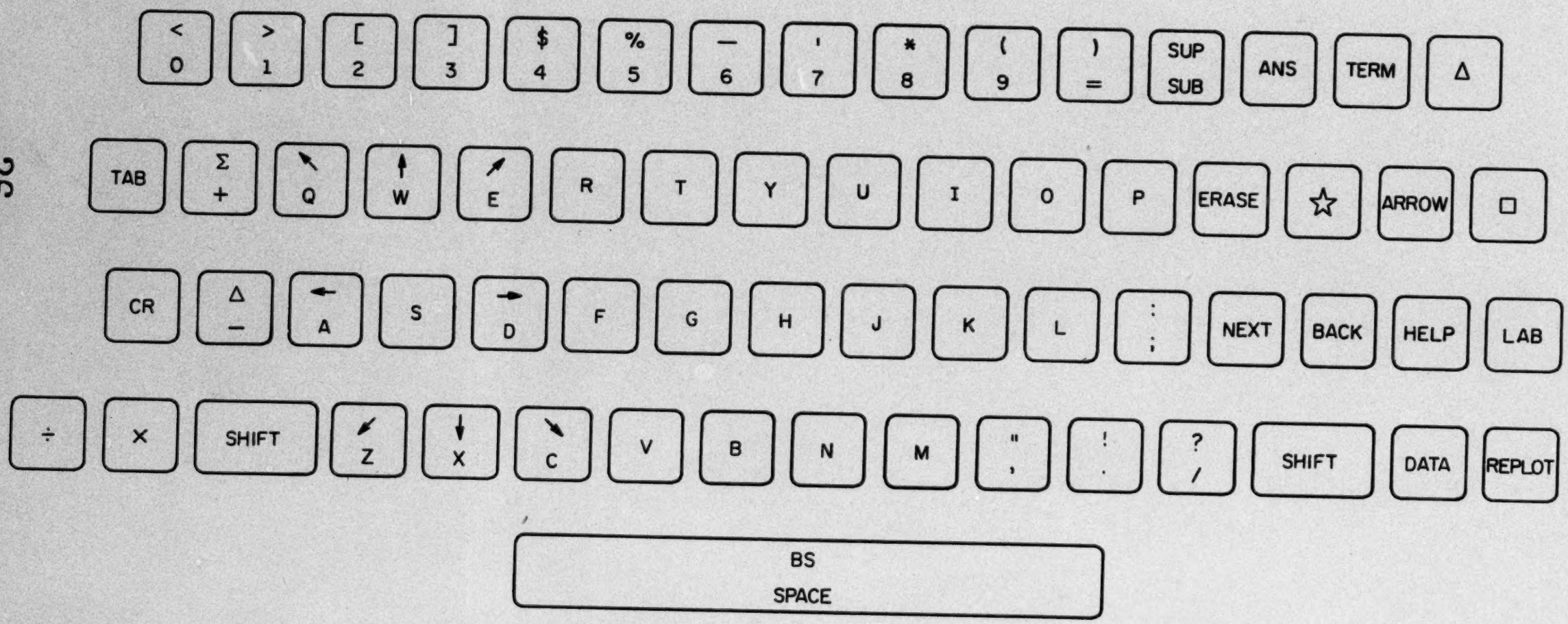
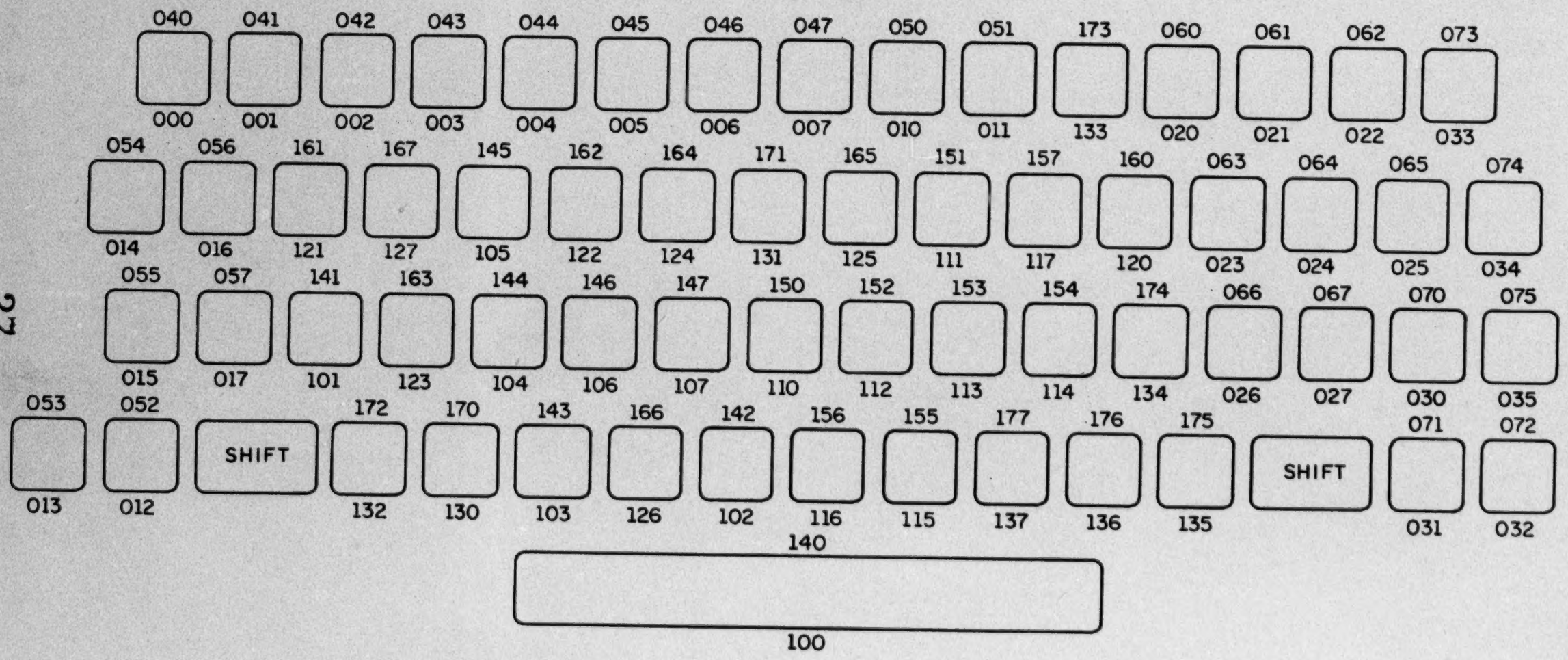


Figure 3.0 KEYBOARD



NOTE: 1. Each key has two different inputs. The octal number below the box is the input when a key is pressed singly (normal state), and the number above the box is the input when the "Shift" key is held down as a key is pressed (shift state).

The "Shift" key alone does not initiate input data transfer, but merely causes an addition of 040 (octal) to a normal input.

2. There is a total of 124 different inputs.

3. The input codes 036, 037, 076, and 077 are not used.

Figure 3.1 KEYBOARD CODING

Where several terminals (up to 32) share a common link to the computer center the data is sent to a multiplexor which assigns a terminal identity code and adjusts the parity bit before transmitting the data on to the center. In this case, the data has the format shown in Figure 3.3. Except for the identity code, bit assignments are the same as in Figure 3.2.

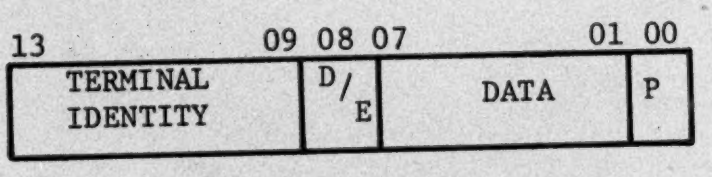


Figure 3.3 Multiplexed Word Format

NAVY

3 Chief of Naval Research
Code 458
Department of the Navy
Washington, D.C. 20360

1 Director
ONR Branch Office
495 Summer Street
Boston, Massachusetts 02210

1 Director
ONR Branch Office
219 South Dearborn Street
Chicago, Illinois 60604

1 Director
ONR Branch Office
1030 East Green Street
Pasadena, California 91101

1 Contract Administrator
Southeastern Area
Office of Naval Research
2110 G Street, N.W.
Washington, D.C. 20037

10 Commanding Officer
Office of Naval Research
Box 39
Fleet Post Office
New York, New York 09510

1 Office of Naval Research
Area Office
207 West Summer Street
New York, New York 10011

1 Office of Naval Research
Area Office
1076 Mission Street
San Francisco, California 94103

6 Director
Naval Research Laboratory
Washington, D.C. 20390
Attn: Technical Information
Division

20 Defense Documentation Center
Cameron Station, Building 5
5010 Duke Street
Alexandria, Virginia 22314

1 Superintendent
Naval Postgraduate School
Monterey, California 93940
Attn: Code 2124

1 Head, Psychology Branch
Neuropsychiatric Service
U. S. Naval Hospital
Oakland, California 94627

1 Commanding Officer
Service School Command
U. S. Naval Training Center
San Diego, California 92133

3 Commanding Officer
Naval Personnel Research Activity
San Diego, California 92152

1 Commanding Officer
Naval Air Technical Training Center
Jacksonville, Florida 32213

1 Officer in Charge
Naval Medical Neuropsychiatric
Research Unit
San Diego, California 92152

1 Dr. James J. Regan
Naval Training Device Center
Orlando, Florida 32813

1 Chief, Aviation Psychology Division
Naval Aerospace Medical Institute
Naval Aerospace Medical Center
Pensacola, Florida 32512

1 Chief, Naval Air Reserve Training
Naval Air Station
Box 1
Glenview, Illinois 60026

1 Chairman
Leadership/Management Committee
Naval Sciences Department
U. S. Naval Academy
Annapolis, Maryland 21402

1 Technical Services Division
National Library of Medicine
8600 Rockville Pike
Bethesda, Maryland 20014

1 Behavioral Sciences Department
Naval Medical Research Institute
National Naval Medical Center
Bethesda, Maryland 20014
Attn: Dr. W.W. Haythorn, Director

1 Commanding Officer
Naval Medical Field Research Laboratory
Camp Lejeune, North Carolina 28542

1 Director
Aerospace Crew Equipment Department
Naval Air Development Center, Johnsville
Warminster, Pennsylvania 18974

1 Chief, Naval Air Technical Training
Naval Air Station
Memphis, Tennessee 38115

1 Commander
Operational Test and Evaluation Force
U.S. Naval Base
Norfolk, Virginia 23511

1 Office of Civilian Manpower Management
Department of the Navy
Washington, D.C. 20350
Attn: Code 023

1 Chief of Naval Operations, Op-37
Fleet Readiness & Training Division
Department of the Navy
Washington, D.C. 20350

1 Chief of Naval Operations, Op-07TL
Department of the Navy
Washington, D.C. 20350

1 Capt. J.E. Rasmussen, MSC, USN
Chief of Naval Material (MAT 031M)
Room 1323, Main Navy Building
Washington, D.C. 20360

1 Naval Ship Systems Command, Code 03H
Department of the Navy
Main Navy Building
Washington, D.C. 20360

1 Chief
Bureau of Medicine and Surgery
Code 513
Washington, D.C. 20360

9 Technical Library
Bureau of Naval Personnel (Pers-11b)
Department of the Navy
Washington, D.C. 20370

3 Director
Personnel Research Laboratory
Washington Navy Yard, Building 200
Washington, D.C. 20390
Attn: Library

1 Commander, Naval Air Systems Command
Navy Department AIR-4133
Washington, D.C. 20360

1 Commandant of the Marine Corps
Headquarters, U. S. Marine Corps
Code A01B
Washington, D.C. 20380

ARMY

1 Human Resources Research Office
Division #6, Aviation
Post Office Box 428
Fort Rucker, Alabama 36360

1 Human Resources Research Office
Division #3, Recruit Training
Post Office Box 5787
Presidio of Monterey, California
93940
Attn: Library

1 Human Resources Research Office
Division #4, Infantry
Post Office Box 2086
Fort Benning, Georgia 31905

1 Department of the Army
U.S. Army Adjutant General School
Fort Benjamin Harrison, Indiana
46216
Attn: AGCS-EA

1 Director of Research
U.S. Army Armor Human Research Unit
Fort Knox, Kentucky 40121
Attn: Library

1 Dr. George S. Harker
Director, Experimental Psychology
Division
U.S. Army Medical Research Laboratory
Fort Knox, Kentucky 40121

1 Research Analysis Corporation
McLean, Virginia 22101
Attn: Library

1 Human Resources Research Office
Division #5, Air Defense
Post Office Box 6021
Fort Bliss, Texas 79916

1 Human Resources Research Office
Division #1, Systems Operations
300 North Washington Street
Alexandria, Virginia 22314

1 Director
Human Resources Research Office
The George Washington University
300 North Washington Street
Alexandria, Virginia 22314

1 Armed Forces Staff College
Norfolk, Virginia 23511
Attn: Library

1 Chief
Training and Development Division
Office of Civilian Personnel
Department of the Army
Washington, D.C. 20310

1 U. S. Army Behavioral Science
Research Laboratory
Washington, D.C. 20315

1 Walter Reed Army Institute of
Research
Walter Reed Army Medical Center
Washington, D. C. 20012

1 Behavioral Sciences Division
Office of Chief of Research and
Development
Department of the Army
Washington, D.C. 20310

1 Dr. Vincent Cieri
U. S. Army Signal School
CAI Project
Fort Monmouth, New Jersey

AIR FORCE

1 Director
Air University Library
Maxwell Air Force Base
Alabama 36112
Attn: AUL-8110

1 Cadet Registrar (CRE)
U. S. Air Force Academy
Colorado 80840

1 Headquarters, ESD
ESVPT
L.G. Hanscom Field
Bedford, Massachusetts 01731
Attn: Dr. Mayer

1 6570 AMRL (MRHT)
Wright-Patterson Air Force Base
Ohio 45433
Attn: Dr. G. A. Eckstrand

1 Commandant
U.S. Air Force School of Aerospace
Medicine
Brooks Air Force Base, Texas 78235
Attn: Aeromedical Library
(SMSDL)

1 6570th Personnel Research
Laboratory
Aerospace Medical Division
Lackland Air Force Base
San Antonio, Texas 78236

1 AFOSR (SRLB)
1400 Wilson Boulevard
Arlington, Virginia 22209

1 Headquarters, U.S. Air Force
Chief, Analysis Division (AFPDPL)
Washington, D.C. 20330

1 Headquarters, U.S. Air Force
Washington, D. C. 20330
Attn: AFPTRTB

1 Headquarters, U.S. Air Force
AFRDDG
Room 1D373, The Pentagon
Washington, D.C. 20330

1 Research Psychologist
SCBB, Headquarters
Air Force Systems Command
Andrews Air Force Base
Washington, D.C. 20331

MISCELLANEOUS

1 Mr. Joseph J. Cowan
Chief, Personnel Research Branch
U.S. Coast Guard Headquarters
PO-1, Station 3-12
1300 E Street, N.W.
Washington, D.C. 20226

1 Director
Defense Atomic Support Agency
Washington, D.C. 20305

1 Executive Officer
American Psychological Association
1200 Seventeenth Street, N.W.
Washington, D.C. 20036

1 Dr. W. A. Bousfield
Department of Psychology
University of Connecticut
Stoors, Connecticut 06268

1 Dr. Lee J. Cronbach
School of Education
Stanford University
Stanford, California 94305

1 Professor L. E. Davis
Graduate School of Business
Administration
University of California, Los Angeles
Los Angeles, California 90024

1 Dr. Philip H. DuBois
Department of Psychology
Washington University
Lindell & Skinker Boulevards
St. Louis, Missouri 63130

1 Dr. Jack W. Dunlap
Dunlap and Associates
Darien, Connecticut 06820

1 Professor W. K. Estes
The Rockefeller University
New York, New York 10021

1 Dr. John C. Flanagan
American Institutes for Research
Post Office Box 1113
Palo Alto, California 94302

1 Dr. Frank Friedlander
Division of Organizational Sciences
Case Institute of Technology
Cleveland, Ohio 10900

1 Dr. Robert Glaser
Learning Research and Development
Center
Univeristy of Pittsburgh
Pittsburgh, Pennsylvania 15213

1 Dr. Bert Green
Department of Psychology
Carnegie-Mellon University
Pittsburgh, Pennsylvania 15213

1 Dr. J. P. Guilford
University of Southern California
3551 University Avenue
Los Angeles, California 90007

1 Dr. Harold Gulliksen
Department of Psychology
Princeton University
Princeton, New Jersey 0540

1 Dr. M. D. Havron
Human Sciences Research, Inc.
Westgate Industrial Park
7710 Old Springhouse Road
McLean, Virginia 22101

1 Dr. Albert E. Hickey
Entelek, Incorporated
42 Plesant Street
Newburyport, Massachusetts 01950

1 Dr. William A. Hunt
Department of Psychology
Loyola University, Chicago
6525 North Sheridan Road
Chicago, Illinois 60626

1 Dr. Howard H. Kendler
Department of Psychology
University of California
Santa Barbara, California 93106

1 Dr. Robert R. Mackie
Human Factors Research, Inc.
6780 Cortona Drive
Santa Barbara Research Park
Goleta, California 93107

1 Dr. A. B. Nadel
General Learning Corporation
5454 Wisconsin Avenue, N.W.
Washington, D.C. 20015

1 Dr. Slater E. Newman
Department of Psychology
North Carolina State University
Raleigh, North Carolina 27607

1 Dr. C. E. Noble
Department of Psychology
University of Georgia
Athens, Georgia 30601

1 Dr. Henry S. Odbert
National Science Foundation
1800 G Street, N.W.
Washington, D.C. 20550

1 Dr. Harry J. Older
Software Systems, Inc.
5810 Seminary Road
Falls Church, Virginia 22041

1 Dr. Leo J. Postman
Institute of Human Learning
University of California
2241 College Avenue
Berkeley, California 94720

1 Dr. Joseph W. Rigney
Electronics Personnel Research Group
University of Southern California
University Park
Los Angeles, California 90007

1 Dr. Arthur I. Siegel
Applied Psychological Services
Science Center
404 East Lancaster Avenue
Wayne, Pennsylvania 19087

1 Dr. Arthur W. Staats
Department of Psychology
Unversity of Hawaii
Honolulu, Hawaii 96822

1 Dr. Lawrence M. Stolurow
Harvard Computing Center
6 Appian Way
Cambridge, Massachusetts 02138

1 Dr. Donald W. Taylor
Department of Psychology
Yale University
333 Cedar Street
New Haven, Connecticut 06510

1 Dr. Ledyard R. Tucker
Department of Psychology
University of Illinois
Urbana, Illinois 61801

1 Dr. Karl L. Zinn
Center for Research on Learning
and Training
University of Michigan
Ann Arbor, Michigan 48104

1 Dr. James J. Asher
Department of Psychology
San Jose State College
San Jose, California 95114

1 Dr. Albert E. Goss
Department of Psychology
Douglass College, Rutgers
The State University
New Brunswick, New Jersey 08903

1 Mr. Halim Ozkaptan, Chief
Human Factors
Martin Company
Orlando, Florida 32809

1 Dr. Alvin E. Goins, Executive Secretary
Personality and Cognition Research
Review Committee
Behavioral Sciences Research Branch
National Institute of Mental Health
5454 Wisconsin Avenue, Room 10A11
Chevy Chase, Maryland 20203

1 Headquarters USAF (AFPTRD)
Training Devices and Instructional
Technology Division
Washington, D.C. 20330

1 Director
Education and Training Sciences
Department
Naval Medical Research Institute
Building 142
National Naval Medical Center
Bethesda, Maryland 20014

1 Dr. Mats Bjorkman
University of Umea
Department of Psychology
Umea 6, Sweden

1 LCDR J.C. Meredith, USN (Ret.)
Institute of Library Research
University of California, Berkeley
Berkeley, California 94720

1 Executive Secretariat
Interagency Committee on Manpower
Research
Room 515
1738 M Street, N.W.
Washington, D.C. 20036
Attn: Mrs. Ruth Relyea)

1 Dr. Marshall J. Farr
Assistant Director, Engineering
Psychology Program
Office of Naval Research (Code 455)
Washington, D.C. 20360

1 Mr. Joseph B. Blankenheim
NAVELEX 0474
Munitions Building, Rm. 3721
Washington, D.C. 20360

1 Technical Information Exchange
Center for Computer Sciences
and Technology
National Bureau of Standards
Washington, D.C. 20234

1 Technical Library
U. S. Naval Weapons Laboratory
Dahlgren, Virginia 22448

1 Technical Library
Naval Training Device Center
Orlando, Florida 32813

1 Technical Library
Naval Ship Systems Command
Main Navy Building, Rm. 1532
Washington, D.C. 20360

1 Technical Library
Naval Ordnance Station
Indian Head, Maryland 20640

1 Naval Ship Engineering Center
Philadelphia Division
Technical Library
Philadelphia, Pennsylvania 19112

1 Library, Code 0212
Naval Postgraduate School
Monterey, California 93940

1 Technical Reference Library
Naval Medical Research Institute
National Naval Medical Center
Bethesda, Maryland 20014

1 Technical Library
Naval Ordnance Station
Louisville, Kentucky 40214

1 Library
Naval Electronics Laboratory Center
San Diego, California 92152

1 Technical Library
Naval Undersea Warfare Center
3202 E. Foothill Boulevard
Pasadena, California 91107

1 Dr. Russ L. Morgan (MRHT)
Training Research Division
Human Resources Laboratory
Wright-Patterson Air Force Base
Ohio 45433

1 Headquarters, Air Training Command
Randolph Air Force Base, Texas
78148
Attn: ATXTD (Dr. Meyer)

1 Mr. Michael Macdonald-Ross
International Training and Education
Company Limited
ITEC House
29-30 Ely Place
London EC1
ENGLAND

1 Commanding Officer
U. S. Naval Schools Command
Mare Island
Vallejo, California 94592

1 Dr. Don C. Coombs, Assistant Director
ERIC Clearinghouse
Stanford University
Palo Alto, California 94305

1 CDR H. J. Connery, USN
Scientific Advisory Team (Code 71)
Staff, COMASWFORLANT
Norfolk, Virginia 23511

1 ERIC Clearinghouse
Educational Media and Technology
Stanford University
Stanford, California

1 ERIC Clearinghouse
Vocational and Technical Education
Ohio State University
Columbus, Ohio 43212

1 Dr. Benton J. Underwood
Department of Psychology
Northwestern University
Evanston, Illinois 60201

Security Classification

DOCUMENT CONTROL DATA - R & D

Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY *(Corporate author)*
University of Illinois, Board of Trustees
Computer-based Education Research Laboratory
Urbana, Illinois 61801

2a. REPORT SECURITY CLASSIFICATION
Unclassified

2b. GROUP

3. REPORT TITLE

A PLASMA DISPLAY TERMINAL

4. DESCRIPTIVE NOTES *(Type of report and, inclusive dates)*

5. AUTHOR(S) *(First name, middle initial, last name)*

STIFLE, Jack

6. REPORT DATE
March, 1970; Revised March 1971

7a. TOTAL NO. OF PAGES
23

7b. NO OF REFS
0

8a. CONTRACT OR GRANT NO.
DAAB 07-67-C-0199; also in part USNSF GJ 81

b. PROJECT NO.

c.

d.

9a. ORIGINATOR'S REPORT NUMBER(S)
CERL Report X-15

9b. OTHER REPORT NO(S) *(Any other numbers that may be assigned this report)*
UILU-ENG 70-205

10. DISTRIBUTION STATEMENT

This document has been approved for public release and sale; its distribution is unlimited.

11. SUPPLEMENTARY NOTES

12. SPONSORING MILITARY ACTIVITY
Advanced Research Projects Agency,
Office of Naval Research

13. ABSTRACT

This report describes a graphics terminal designed for use as a remote computer input-output terminal. The terminal features a plasma display panel, self-contained character and line generators and the ability to communicate over voice grade telephone circuits.

DD FORM 1 NOV 65 1473 (PAGE 1)
S/N 0101-807-0811

Security Classification

A-31408

Security Classification

14 KEY WORDS	LINK A		LINK B		LINK C	
	ROLE	WT	ROLE	WT	ROLE	WT
Computer-assisted Instruction						
Computer-based Instruction						
PLATO						
PLATO IV						
Plasma Display						
Remote Computer Terminal						
Character Generator						
Line Generator						

DD FORM 1 NOV 65 1473 (BACK)

Security Classification